



## EPOXY POLYMER CONCRETE OVERLAY MSP-00-01B

### 1.0 GENERAL

**1.1** This work shall consist of furnishing and applying thin polymer concrete overlays in a prime coat plus two courses on designated bridge structures in accordance with this special provision. The total thickness of the overlay shall be a minimum of 1/4 inch.

**1.2** The overlay manufacturer's representative shall be present at all times that work is in progress until final acceptance of the overlay. The manufacturer's representative shall make recommendations to the engineer as to the acceptability of every phase of the operation, which includes but is not limited to surface preparation of the bridge deck, type of equipment, mixing of the overlay components, type of application, method of application, and finish.

### 2.0 MATERIALS

**2.1 Epoxy Resin Materials.** The infrared spectrum for each component of the epoxy-resin materials shall essentially match that of the standard infrared spectrum for the particular component as specified in AASHTO T237, Sections 4 and 5. The epoxy shall consist of Component A and Component B. The epoxide equivalent for Component A shall not exceed 270. The mixed epoxy shall meet the following requirements:

Pot life @ 75 F [24C] (minutes)	10 min.	55 max.
Tensile strength @ 75 F [24C] @ 7 days min. (psi) [MPa]	1500 min. [10.3 min.]	--
Tensile elongation @ 75F [24C] (%)	20 min.	--
Water absorption (%)	--	0.8 max.
Compressive strength (psi, 4 hr., min.) [MPa, 4 hr., min.]	1000 min. [6.8 min.]	--
Compressive strength (psi, 48 hr., wet) [MPa, 48 hr., wet]	4000 min. [27.5 min.]	--
Ash content (%)	--	0.5 max.
Viscosity (Poises @ 75F) [24C]	7 min.	25 max.
Spindle No. (paddle size)		3
Speed		60
Volatile content (max., %)		3.0

**2.1.1 Classes.** Epoxy resin shall be formulated for use at specific temperatures. Classes of systems are defined according to the range of temperatures for which they are suited and are specified in ASTM C-881. The controlling temperature shall be that of the surface of the hardened concrete to which the bonding system is applied.

**2.1.2** Where unusual curing rates are desired and upon the approval of the engineer, a class of bonding agent may be used at a temperature other than that for which it is normally intended.

**2.2 Testing.** Tests will be performed in accordance with the following methods:

Characteristic	Test Method	Other
Viscosity	ASTM 2393 Model LVT Brookfield viscometer	Determination made at temperature given in <b>Section 2.0 of this provision</b> for class of materials
Epoxide equivalent	ASTM D1652 as modified by <b>Section 2.2.2 of this provision</b>	
Volatile content	ASTM D1259, Method B, for mixed system	Sample cured 4 days at room temperature and weighed on previously weighed metal foil
Filler content	<b>Section 2.2.2 of this provision</b>	
Ash content	ASTM D482	
Pot life	AASHTO T237	Determination made at temperature given in <b>Section 2.0 of this provision</b> for class of materials
Tensile strength	ASTM D638	
Compressive strength	ASTM C 881	
Water absorption	ASTM D570	
Thermal shear	<b>Section 2.2.1 of this provision</b>	

## 2.2.1 Test Method for Thermal Shear or Shrinkage Test of an Epoxy Overlay Mortar Applied to Concrete

**2.2.1.1 Scope.** This method covers the bond of an epoxy resin overlay system to portland cement concrete when subjected to temperature cycles of 5F to 110F [-15C to 45C].

**2.2.1.2 Procedure.** Blocks of B1 concrete are cast in pans and the edges sawed at right angles to the top to make a block 11 x 8 x1.5 in [279 x 203 x 38 mm]. The top circumference of the block is taped so that 0.375 to 0.500 in. [10 mm to 13 mm] extends above the top level surface. A mortar mixed with ASTM C 109 sand and the epoxy proportioned as per the manufacturer's recommendations is placed on the block and consolidated with a laboratory vibrator and struck off smooth with a straight edge. The concrete overlay is allowed to cure in air for 3 days and in the moisture room 4 days, after which it is subjected to 10 cycles 17 hours in freezer at 5F [-15C] and 7 hours at 110F [45C]. The surface of the epoxy overlay is measured before and after cycling to a tolerance of  $\pm 1/16$  in [2 mm].

**2.2.1.3 Significance.** Shearing, shrinkage, or expansion of the epoxy mortar is an indication of probable incompatibility of the epoxy system applied to a concrete surface or pothole and shall be cause for rejection. Also, evidence of scaling of the epoxy is cause for rejection.

## 2.2.2 Test Method for Filler Content of Epoxy Resins With Adjustments for Epoxide Equivalent Designation:

ASTM Method: D 1652, shall be followed, with the following additions:

### 1. Filler Content

Weigh, to the nearest 0.1 mg, ten (10) grams of the epoxy resin component into a 150-ml beaker. Add 50 ml of methyl ethyl ketone (MEK) to the beaker, and stir the contents until all the

soluble matter is dissolved. Dry a medium-porosity fritted-disc filtering crucible to constant weight to  $110 \pm 5^\circ\text{C}$ . Wet the filter with MEK, then filter the contents of the beaker with the aid of vacuum through the filtering crucible. Transfer the contents of the beaker entirely to the crucible, and wash the beaker and the residue on the filter with MEK. The total volume of solvent used to transfer and wash the residue should be about 200 ml. Dry the filter and residue to constant weight at  $110 \pm 5^\circ\text{C}$ . Calculate the percentage of filler in the component, and report the value to the nearest 0.1 percent. If the sample is black, due to the presence of asphalt material, the solvent used shall be a maximum of 1:1 MEK and benzene, by volume.

## 2. Epoxy Equivalent

- a) Calculate the weight per epoxy equivalent after correcting for the filler and volatile contents of the component as follows:

$$x = y (1.0 - f - v)$$

Where	x =	corrected weight per epoxy equivalent of the epoxy resin fraction of the component.
	y =	weight per epoxy equivalent of the total component as determined by Method D 1652.
	f =	weight fraction of filler in the component.
	v =	weight fraction of volatile matter in the component.

- b) Weigh, to the nearest 0.1 mg, an evaporating dish. Using a 10 ml. disposable syringe, add 10 ml. of component A to the evaporating dish and re-weigh, recording all weights. Ignite evaporating dish to char sample. Place evaporating dish in muffle furnace for 2 hours. Remove, cool, then reweigh. The residual weight of the sample is used to calculate the filler content.

**2.3 Aggregate.** Aggregate shall be bauxite, crushed porphyry, aluminum oxide, flint chat or other similarly hard, durable aggregates, dry with less than 0.2% moisture, as recommended by the epoxy supplier and approved by the engineer. Aggregate shall conform to the following gradation:

<u>Sieve Size</u>	<u>% Passing By Weight</u>
# 4 [4.75 mm]	100
# 20 [850 $\mu\text{m}$ ]	0-5
# 200 [75 $\mu\text{m}$ ]	0-1.0

**2.3.1** Aggregate produced as a by-product from lead or zinc mining operations shall not have a total lead content greater than 4,500 ppm, as determined by EPA Method 3050A, Acid Digestion of Sediments, Sludges and Soils (particle size reduced to 1 mm or less). Suppliers of this aggregate shall provide a certification to the engineer for each shipment, that the total lead content of the aggregate does not exceed this value, and attach a typical test report from the same source no older than 12 months from the date of shipment.

**2.3.2** For each contract, the epoxy supplier shall supply a letter to the engineer specifically recommending the use of a designated aggregate and source, which has been qualified.

**2.3.3** The following local aggregate sources have been pre-approved for use, providing that the epoxy supplier concurs: Flint Chat, Flint Rock Products, Picher, OK 74360, Wet Bottom Boiler Slag (Black Beauty), Reed Minerals, LaCygne, KS 66040, and Mark-371 Aggregate, Poly-Carb, Inc., Solon, OH 44139.

**2.4 Qualification of Materials.** Qualification must be obtained prior to use of the product on a project.

**2.4.1 Epoxy.** The epoxy manufacturer shall submit to the State Construction and Materials Engineer, a sample of the epoxy resin material along with the information required below. The sample shall consist of one quart [one liter] of each component. This qualification does not waive the other criteria required for compliance to this special provision.

**2.4.1.1** The epoxy material shall have a proven record of a minimum of two years on similar bridge decks within the contiguous United States and which can be inspected by the engineer if so desired. A list including the location, the name of the agency involved with the project, and a name and phone number of a contact person with that agency, shall be provided for each location used as evidence of satisfactory use.

**2.4.1.2** A certification statement by the manufacturer indicating that the material meets all requirements of this special provision shall be included. In addition, the manufacturer shall provide specific test results certified by an independent, nationally recognized testing laboratory verifying compliance of the cured resin system with all of the testing requirements indicated herein.

**2.4.2 Aggregate.** Aggregate source qualification may be obtained by, the aggregate supplier or the epoxy supplier, contacting the State Construction and Materials Engineer, Jefferson City, MO, and furnishing satisfactory proof of compliance.

### **3.0 CONSTRUCTION METHODS**

**3.1 Safety Provisions.** Personnel shall be thoroughly trained in the safe handling of materials in accordance with the manufacturer's recommendations. Protective gloves and goggles shall be provided to workers directly exposed to the resin material. All workers shall be provided with Product Safety Data Sheets from the manufacturer.

**3.2 Handling and Storage of Materials.** Information pertaining to the safe practices for the storage, handling, and disposal of the materials and to their explosive and flammability characteristics, health hazards, and the recommended fire fighting equipment shall be obtained from the manufacturer and posted at storage areas. Fire fighting equipment shall be kept readily accessible at storage areas. A copy of such information shall be provided to the engineer.

**3.2.1 Resin Materials.** The two components of the epoxy-resin system shall be furnished in separate containers that are non-reactive with the materials.

**3.2.2** Containers shall be identified as "Component A--Contains Epoxy Resin" and "Component B--Contains Hardener" and shall show the type, class, and mixing directions. Each container shall be marked with the name of the manufacturer; class, batch, or lot number; date of

packaging; date of shelf life expiration; pigmentation, if any; and the quantity contained in pounds [kilograms] and gallons [liters].

**3.2.3** The resin material shall be stored in a heated warehouse in a dry area. Storage temperatures shall be maintained within 50 to 90F [10 to 32C].

**3.2.4 Job Site Storage.** The resin material shall be stored on the job site in a weather protected trailer or building so that it is kept away from moisture and maintained within the temperature range of 50 to 90F [10 to 32C].

**3.2.5 Aggregate.** All aggregate shall be dry and stored in a dry, moisture free atmosphere. The aggregate shall be fully protected from any contaminants on the job site and shall be stored so as not to be exposed to rain or other moisture sources.

**3.3 Field Test.** Prior to commencing the overlay operation, a test area of overlay consisting of a thin prime coat and two layers shall be placed on the bridge deck in a location approved by the engineer. When multiple bridges are included in a project, the test area is required on each bridge. The test area should be large enough so that the cleaning equipment and methods of cleaning to be employed in the full-scale operation may be used. This avoids the possibility of attaining a degree of cleanliness in a small test area which could not be matched later with the equipment to be used in the full-scale operation. The contractor may utilize half of the bridge deck or the area equal to one day's placement operation, whichever is smaller, as a field test. The degree of cleaning used on the test area shall be the minimum used on the remainder of the structure. The surface for the test overlay shall be prepared in accordance with the test method prescribed in ACI 503R - Appendix A of the ACI Manual of Concrete Practice to determine the cleaning practice (size of shot, flow of shot, forward speed of shot blasting machine, and number of passes) necessary to establish an approved cleaning practice.

**3.3.1** The approved cleaning practice shall remove asphaltic materials, oils, dirt, rubber, curing compounds, paint, carbonation laitance, weak surface mortar, and other potentially detrimental materials which may interfere with the bonding or curing of the overlay. Acceptable cleaning is usually achieved by significantly changing the color of the concrete and mortar and beginning to expose coarse aggregate particles. Mortar which is sound and soundly bonded to the coarse aggregate must have open pores due to cleaning to be considered adequate for bond. Areas of asphalt larger than one inch [25 mm] in diameter, or smaller areas spaced less than six inches [152 mm] apart shall be removed. Traffic paint lines shall be considered clean when the concrete has exposed aggregate showing through the paint stripe. A vacuum cleaner or compressed air shall be used to remove all dust and other loose material. The compressor shall be equipped with a filter to prevent oil in the air supply.

**3.3.2** In addition to the above requirements, the cleaning practice shall provide an adhesion strength test result greater than 250 psi [1.7 MPa] or a failure area into the base concrete which is greater than 50% of the test area. After the test area has cured for a minimum of 72 hours, adhesion shall be checked by the contractor in accordance with ACI 503R. A test result shall be the average of three tests on a sample area of the test patch. A minimum of three sample areas per test patch shall be tested with successful test results required from each sample area.

**3.3.3** If the test of a sample area fails to meet the above requirements due to a cohesive failure of the substrate concrete, the adhesive strength of the sample area will be considered acceptable.

**3.3.4** Successful completion of the adhesion strength tests is required before the full-scale

overlay operation is to begin. All cleaning operations shall equal or exceed that used for the area of the adhesion strength test areas, in both profile and cleanliness.

**3.3.5** To provide assurance that the cleaning procedure, materials, installation procedure and curing period will provide the desired overlay, test patches shall be installed with the same materials, equipment, personnel, timing, sequence of operations and curing period prior to opening for traffic, that will be used for the installation of the overlay.

**3.3.6** If the cleaning practice, materials, and installation procedure are not acceptable, the contractor must remove the material represented by the failed test patches and make the necessary adjustments and provide another test patch at no additional cost to the Commission until satisfactory test results are obtained.

**3.4 Surface Preparation.** Before placement of the polymer concrete overlay, the entire deck surface shall be cleaned by the approved cleaning practice established in the field adhesion strength tests.

**3.4.1** If the engineer determines that an approved cleaning practice has changed prior to the completion of the job or that the weather has changed significantly since the application of the field test patch, the contractor must return to the approved cleaning methods and reclean the suspect areas or verify through adhesion tests at no additional cost to the department that the practice is acceptable.

**3.4.2** Construction traffic shall not be allowed on a portion of the deck which has been shot blasted or on the overlay without specific approval of the engineer.

**3.4.3** The deck surface shall be overlaid as soon as possible after the surface preparation operation but in no case shall the time between surface preparation and application of the first course exceed 24 hours.

**3.4.4** All patching and cleaning operations shall be inspected and approved prior to placing each layer of the overlay.

**3.4.5** Any contamination of the deck or to intermediate courses, after initial cleaning, shall be removed. Both courses shall be applied prior to opening the area to traffic.

**3.4.6** There shall be no visible moisture present on the surface of the concrete at the time of application of the polymer concrete overlay. Compressed air may be used to dry the deck surface. The compressor shall be equipped with a filter to prevent oil in the air supply.

**3.5 Equipment.** The contractor's equipment shall consist of no less than an epoxy distribution system, fine aggregate spreader, broom and sweeper broom or vacuum truck, and a source of lighting if work will be performed at night. The distribution system or distributor shall accurately blend the epoxy resin and hardening agent, and shall uniformly and accurately apply the epoxy materials at the specified rate to the bridge deck in such a manner as to cover approximately 100% of the work area. The fine aggregate spreader shall be propelled in such a manner as to uniformly and accurately apply the aggregate to cover 100% of the epoxy material. The sweeper broom or vacuum truck shall be self-propelled.

**3.5.1** With the approval of the engineer, the contractor's equipment may consist of calibrated containers, a paddle type mixer, squeegees, rollers and brooms, which are suitable for mixing the epoxy and applying the epoxy and aggregate in accordance with this special provision. The

epoxy resin and hardening agent shall be accurately blended and uniformly applied at the specified rate. Contents of the separate packages containing Components A and B shall be thoroughly stirred prior to use. The same paddle shall not be used to stir Component A that is used to stir Component B.

**3.6 Mixing Epoxy.** Epoxy resin shall be furnished in two components for combining immediately prior to use in accordance with the manufacturer's instructions. Component A shall contain a condensation product of epichlorohydrin with bisphenol A and shall conform to the requirements of **Section 2.1.1 of this provision**. Component B shall contain one or more hardening agents that will cause the system to polymerize and harden in accordance with the requirements of **Section 2.1.1 of this provision** on mixing with Component A. Thixotropic agents used to control viscosity will be permitted in accordance with the manufacturer's recommendations. If the mixture proportion of Component A to Component B is more than 4:1, only complete units as packaged by the manufacturer shall be used.

**3.6.1** Equipment and tools may be cleaned with toluene, xylol, or methyl ethyl ketone before the adhesive has set. Components A and B shall be stored between 65F and 80F [18C and 26C] for at least 2 hours before use. Epoxy components may be heated in hot water or by indirect heat to bring them to the required temperature prior to mixing. Solvents and thinners shall not be used except for cleaning equipment.

**3.6.2** Mixing of epoxy components shall be in accordance with the manufacturer's instructions.

**3.6.3** When mineral fillers are specified, they shall be inert and nonsettling or readily dispersible. Materials showing a permanent increase in viscosity or the settling of pigments that cannot be readily dispersed with a paddle shall be replaced at the contractor's expense. At least 95 percent of the filler shall pass the No. 300 sieve.

**3.7 Application.** Application of the resin system shall be done by the supplier or by a factory trained or licensed applicator with written approval from the manufacturer of the epoxy system.

**3.7.1** The handling and mixing of the epoxy resin and hardening agent shall be performed in a safe manner to achieve the desired results in accordance with this special provision and with the manufacturer's recommendations as approved or directed by the engineer. Polymer concrete overlay materials shall not be placed when weather or surface conditions are such that the material cannot be properly handled, placed and cured within the specified requirements of traffic control or when rain is forecast within 24 hours of application.

**3.7.2** The epoxy overlay shall consist of a thin prime coat applied with a flat squeegee followed by a two course application of epoxy and aggregate. The prime coat shall be allowed some open time to soak into the concrete, however the first course shall be applied before the prime coat has gelled. The prime coat and first course shall not be placed as one application. Each of the two courses shall consist of a layer of epoxy covered with a layer of aggregate in sufficient quantity to completely cover the epoxy. The thickness of each course shall be approximately equal. The total thickness of the overlay shall not be less than 1/4" [7 mm].

**3.7.3** After the epoxy mixture has been prepared, it shall be immediately and uniformly applied to the surface of the bridge deck with a squeegee or paint roller. The temperature of the bridge deck surface shall be above 55F [12C].

**3.7.4** The dry aggregate shall be applied in such a manner as to cover the epoxy mixture completely within 5 minutes. The dry aggregate shall be sprinkled or dropped vertically in a

manner such that the level of the epoxy mixture is not disturbed.

**3.7.5** The first course shall be swept to remove loose aggregate prior to second course application, when sweeping can be done without removing aggregate from the epoxy. First course applications which do not receive enough aggregate prior to gel shall be removed and replaced.

**3.7.6** A second course applied with insufficient aggregate may be left in place, but will require additional applications before opening to traffic. In this case, the engineer may require additional adhesion strength tests by the contractor in accordance with ACI 503R to verify the contractor's procedure.

**3.7.7** The thickness of the overlay shall be verified to be at least 1/4" [7 mm] thick (measured from the deck surface to the top of the resin). The contractor shall provide 1/2" [13 mm] diameter (minimum) holes at a minimum rate of one hole per 100 feet [30 meters] of traffic lane at locations designated by the engineer. Thin areas shall be recoated and re-verified at no additional cost to the Commission.

**3.7.8** Where additional applications are required for thin areas or insufficient aggregate, the engineer may require additional adhesion strength tests by the contractor in accordance with ACI 503R to verify the contractor's procedure.

**3.7.9** All adhesion strength test areas, thickness test holes, or any debonded areas shall be repaired (filled with polymer concrete in accordance with this special provision) before final acceptance.

**3.7.10** The epoxy concrete overlay shall be cured at least one hour, or until brooming or vacuuming can be performed without tearing or otherwise damaging the surface and no traffic or equipment shall be permitted on the overlay surface during the curing period.

**3.7.11** After the curing period, all loose aggregate shall be removed by brooming or vacuuming and the next overlay course applied to completion.

**3.7.12** Under no circumstances shall any polymer mixture be allowed to run into drains.

**3.7.13** Unless otherwise specified the epoxy concrete overlay courses shall be applied over the expansion joints and joint seals of the bridge deck. The expansion joints and joint seals shall be provided with a bond breaker. Prior to opening any application to traffic, the overlay shall be removed over each joint by removal of tape, bond breakers, or by scoring the overlay prior to gelling, or by saw cutting after cure.

**3.7.14** The contractor shall plan and prosecute the work so as to provide at least three hours' cure or other minimum cure as prescribed by the manufacturer prior to opening that section to public or construction traffic, unless otherwise permitted.

**3.7.15** During night operations, or other times of slow curing, the minimum time shall be increased as prescribed by the manufacturer so that the compressive strength of the overlay mixture is 1000 psi [6.9 MPa] prior to opening to traffic. First course applications shall not be opened to traffic.

**3.7.16** In the event the contractor's operation damages or mars the epoxy concrete overlay course(s) or the epoxy concrete overlay debonds, the contractor shall remove the damaged



area(s) by saw-cutting in rectangular sections to the top of the concrete deck surface and shall replace the various courses in accordance with this special provision in a manner acceptable to the engineer at no additional cost.

**3.7.17** In the event the contractor's method of operation or epoxy mixture is outside the limitations provided herein, the overlay as placed will be removed to the satisfaction of the engineer.

**4.0 ACCEPTANCE.** The material shall be accepted based upon satisfactory qualification, required certifications, sampling as designated by the Engineer, and satisfactory performance in the field.

**4.1 Certification for Compliance.** The material manufacturer shall furnish a notarized certification that the material complies with the requirements of this special provision, including the required aggregate certifications. It shall not be inferred that the provision of a certification of compliance waives state inspection, sampling or testing.

## **5.0 METHOD OF MEASUREMENT**

**5.1** The area of polymer concrete overlay will be measured and computed to the nearest square yard [square meter]. This area will be measured longitudinally from fill face to fill face and transversely between roadway face of curbs excluding the area of the expansion device if any.

**5.2** Final measurement will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

## **6.0 BASIS OF PAYMENT**

**6.1** Payment for the above-described work including all materials, equipment, labor and any other incidental work necessary to complete this item shall be considered as completely covered by the contract unit price for "Epoxy Polymer Concrete Overlay," per square yard [square meter].